UNIT 19 INTELLIGENT SUPPORT SYSTEMS

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19.1 INTRODUCTION

The need for intelligent support systems has arisen because a need was felt to solve not-so-trivial problems by way and means of systems that are much more capable than humans. It was felt necessary to use skillfully coded real-world knowledge and rules in to a computer, which in turn simplifies the problem solving effort. Expert systems and knowledge-based systems are efforts in this direction. Evolution of techniques like artificial neural networks, fuzzy logic and genetic algorithms has really enhanced the problem-solving capacity of these systems. In this unit we will give you a brief introduction about them so that you can appreciate these concepts.

19.2 OBJECTIVES

After reading this unit you should be able to:

- Explain artificial intelligence, and expert systems;
- Describe Neural Networks, Genetic Algorithms and Fuzzy Logic;
- Explain the efforts made in creation of these systems; and
- Identify and discuss their advantages in business applications.

19.3 ARTIFICIAL INTELLIGENCE

The advent of Artificial Intelligence (AI) is as old as a half decade when the first modern computer emerged. Frankly, what a computer does is that it simulates collective thinking of several humans to process high volumes of data at a high speed and accuracy. We are witnessing a shrink in the size and cost of the computer, but there is growth in its capability. The growth in capabilities actually means that computers are becoming more and more competent of delivering more than the

human abilities. These enhanced competencies are then used to deliver more power in business activities. The goal of the AI scientists had always been to develop a thinking machine that solves problems in a way that would be considered "intelligent" if done by a human. This forms the basis of our definition to artificial intelligence. Oxford dictionary defines the two terms as "artificial" means not natural or imitating nature and "intelligence" as quickness in understanding the information. The term AI was first introduced three decades ago by McCarthy, "Intelligence is the computational part of the ability to achieve goals in the world". Artificial intelligence (AI) thus can be defined as a field that focuses on building techniques to enable computer systems to perform activities that are quick and are above human intelligence. Patterson (1990) defined artificial intelligence, as "AI is a branch of computer science concerned with the study and creation of computer systems that exhibit some form of intelligence: systems that learn new concepts and tasks, systems that can reason and draw useful conclusions about the world around us, systems that can understand a natural language or perceive and comprehend a visual scene, and systems that perform other types of feats that require human types of intelligence". Konar (1999) defined AI as "the simulation of human intelligence on a machine, so as to make the machine efficient to identify and use the right piece of 'knowledge' at a given step of solving a problem".

The need for AI has arisen because a need was felt because but for the tiny and trivial problems, it was becoming very difficult to solve not-so-trivial problems. It was the wastage of time and effort. To counter this, it was felt necessary to use skillfully coded real-world knowledge and rules in to a computer, which in turn simplifies the problem solving effort.

19.3.1 Brief History of AI

As mentioned earlier, AI has roots as old as half a decade when the computer became a commercial reality. It will be interesting to have a feel as to how these developments occurred and finally took the shape in which AI is today. The table given below is the time-line of the developments in the filed of AI

Table 19.1: Brief History of AI

S.No	Period	Works
1	Works before 50's	Demonstration that a simple computer processor (Turing Machine) is capable of manipulating symbols as well as numbers (machine intelligence), emergence of cybernetics (study of communication between human & machine) as a field, new approaches to language theories, computer becomes a commercial reality, emergence of theories like information theory, Boolean algebra, switching theory and statistical decision theory
2	Works after 50's	Development of chess playing programs, works like language translation, automatic theorem proving and new programming languages. Development of FORTRAN, LISP, computational linguistics, pattern recognition & natural language processing
3	Works in the 60's	Program to play checkers, resolution as an inference method in logic; first knowledge based expert system (DENDRAL), development of a large interactive general purpose program that solves mathematical problems and simulation of complicated processes of thinking.
4	Works in mid 70's to present	Solving more complex problems of practical interest, expert systems that diagnose and prescribe medicines, expert systems that deals with real-life problems, uncertainty modeling, non-monotonic and spatio-temporal reasoning etc. specialized programs about narrow problem areas.

(Based on Patterson, 1990)

We can see that all these developments were the result of the desire of the human beings to solve problems that were not so trivial. To overcome the difficulties that were faced in solving these problems, they thought of putting intelligence into a computer (essentially based on the knowledge of the then society). The theme of all these efforts was around the concept of making a program intelligent, by providing it with high quality specific knowledge about some problem area. This collaborative and collective intelligence led the machine do the tasks better than the humans. AI has taken off from there and what we are getting today is an improved build-up on the older systems. Let us see what are the goals on which AI work.

19.3.2 Goals of AI

AI works on the following goals:

1. **Emulate Humans:** From the very basic definitions of AI it has become clear that AI's main goal is to identify solvable and out of the ordinary information processing problems, and solve them. In other words, AI's primary goal is to emulate human intelligence and not only emulate but do things in a better way.
2. **Solve Problems that Require Intelligence:** Be it a program that plays chess or a system that has all the intelligence of a dictionary, the primary aim of the AI has always remained to study and solve problem that are knowledge intensive and require a high degree of intelligence.
3. **Develop Expert Systems on Real-Life Problems:** AI has real-life problems in the world as its pivot. AI's goal is to develop experts systems that simulate the real-world problems and solve them automatically.
4. **Enhance Interaction:** AI works for enhancing human-human, human-computer and computer-computer interaction. Computers have now accepting more and more varied use-interfaces for input and output processes like voice, vision and virtual reality etc.

Table 19.2: Generations of Computers

S. No.	Generation	Description	Capability
1	*First Generation*	Inspired by Babbage's analytical engine, these computers were made of thermo-ionic valves.	Could perform "number crunching operations"
2	*Second Generation*	These computers were made of transistors and were smaller in size as compared to their predecessors.	Mainly used for commercial data processing and payroll creation.
3	*Third Generation*	These computers were made of Integrated circuits (IC). Many electro-mechanical robots were based on these.	Could perform massive computations in real-time
4	*Fourth Generation*	These computers came up with high-speed VLSI engines. Many electronic robots were based on these.	Operations became more fast.
5	*Fifth Generation*	Emerged in the period 1981-90 in Japan with AI embedded in them.	Could process "intelligence". Could process natural languages, Play games, recognize images and prove theorems.

Based on *Konar, Amit (1999)*

19.3.3 Applications of AI

AI is employed in virtually every branch of science today. But before going into the details of applications where AI plays a significant role, we will go back to how computers were developed and what were their capabilities at different point of times. Following table gives these details:

One can see that there is a growth in the capabilities of the computers as they move from one generation to the other. In fact, this is addition of more and more intelligence in the systems that are doing wonderful works presently and are poised to do even better in the future.

You can find a lot of varied applications of AI. It has been applied in game playing, automated grammar checking, speech recognition, vision systems, and expert systems like weather forecasting, diagnostic systems, financial decision making and classification systems, computer simulated natural processes, mathematical theorem proving, natural language understanding, intelligent control and scheduling & planning.

Let us consider some of the examples of these applications:

1. **Game Playing:** Chess is one such game for which many programs are created using artificial intelligence. Chess has about 10^{120} states in a typical game. Many of such programs have done remarkably well like getting a grand-master status or getting a high ELO rating etc. Most of these programs were capable of thinking move up to five to six levels ahead. Feeding all possible moves into the computer and making it capable to search the best possible move according to the situation was the strategy of these programs. You make like to recall that Deep Blue Chess program beat world champion Gary Kasparov.

2. **Automated Grammar Checking:** You must have used a word-processor and used its spelling and grammar-checking feature. While spelling checker module works well, there is lot that has to done for the grammar-checking module. The features available in current software are far less than satisfactory. These software fumbles at using proper pronouns, gender or giving proper meaning etc. For an efficient program of this kind, it has to be given "intelligence" about knowledge from the real world.

3. **Speech Recognition:** You must have seen the software that types the words as one speaks. These are called phonetic typewriters. Speech understanding has found good commercial value in the recent times e.g. speech recognition systems are used in reservation through telephone. Dragon Naturally speak, is one such software that needs a mention.

4. **Natural Language Understanding:** To understand a natural language like English one has to understand the syntactic (analysis of grammar, compilation) and semantic (meaning of sentences from association of words) interpretation of words. Robots have been designed that understands few instructions, but days are not far when a robot will fully understand a speech in the natural language. There have been examples where full document have been translated in many different languages. Site's http://babelfish.altavista.com/ translation of web pages, is also based on natural language processing.

5. **Vision Systems:** Any image is a two-dimensional array of pixels. In vision systems, image is processed for noise and partitioned into objects of interest. These objects are recognized and finally the image is interpreted. Many banks uses face recognition programs. There are systems like "intelligent character readers" which recognizes handwriting. Computer vision has many other applications too such as baggage inspection, manufacturing inspection etc.

6. **Expert Systems:** An expert system consists of a knowledge base, database and an inference engine for interpreting the database using the knowledge embedded in the knowledge base. There is sound reasoning process that has to build in order to create an expert system. AI techniques have played significant role in creation of expert systems for weather forecasting; diagnostic systems such as medical diagnosis systems, pathology diagnosis system & customer assistance systems etc.; financial decision making systems like fraud detection systems used in credit card companies & systems that expedite financial transactions and classification systems like financial decision making systems & NASA's galaxy-classification system.

7. **Computer Simulated Natural Processes:** Applications of AI are not limited to human and natural processes, it is extended to other processes too. A model based on AI tools predicts the walk of a cockroach and its basic behaviors. The model correctly predicted many of behavioral processes pertaining to cockroach.

8. **Mathematical Theorem Proving:** There had been many attempts of proving mathematical theorems with the help of AI tools. Inference methods are used to prove new theorems.

9. **Intelligent Control:** firstly an expert controller sets a set of rules. The rule whose premise matches the dynamic plant parameter response is selected and implemented. Fuzzy logic is also used in such cases in many industrial plants e.g. the power control in a nuclear reactor. There are application using fuzzy logic and artificial neural networks for plant estimation i.e. for designing a process estimator.

10. **Scheduling & Planning:** You must be aware of the importance of planning a time schedule of a set of events to improve the efficiency. Artificial neural nets and genetic algorithms have been employed to solve these problems. Typical examples of these applications are class-routine scheduling problem, Automatic scheduling for manufacturing and rerouting scheduler for airlines etc. Operation Desert Storm used these systems for planning logistics of people and supplies.

19.3.4 Building AI

While building artificial intelligence in an organization one has to think about many factors such as observation, reasoning and action. Take the case of a human being; it has sensory functions attached to various parts of its body with which it observe the things in the real world. You might have seen different software for medical diagnosis, e.g. homeopathic software contains a set of symptoms and test results that have been obtained and inputted to the system manually. Whenever a patient inputs its symptoms then the diagnosis system matches it with the recorded ones to give a diagnosis. The second step in this is the reasoning part. This is dependent on the inference, decision-making and classification from what is observed in the first step. There are many tools available for this step. These tools could be artificial neural network, logical deduction system, heuristic searching a problem space, Bayes network inference, genetic algorithms etc. The third and the final step in the building process is the action. We will go back to the example of the human beings. When the observation is done and reasoning is made it is the time for action e.g. if you touch a hot thing, you develop a reasoning that if you touch that, you will be hurt. The action is that you would not touch a hot thing. In real world you may come across different kind of problems. There would be problems that could be not solved by mathematical or logical algorithms. Such problems can only be solved through intuitive algorithms. These problems are the problems that are deemed in to the AI domain. The key to AI approach is intelligent search and matching. If you were given a problem you would be doing the following tasks:

1) **Knowledge Representation and Reasoning:** You will first try to represent the facts in some way. Logic is built to answer questions like "what" & "how". One tries to collect all facts whether missing, implicit, explicit or probabilistic to gather knowledge to solve a problem. You build rules to infer from the knowledge thus collected. In case you have many ways to infer something then you would like to go for the path that is al the smallest distance from the goal.

2) **Heuristic Search:** One has to develop rules of thumb to solve the constraints in the problem space. As we have earlier mentioned that there are about 10^{120} states in a Chess game. As we move from one state to another state we search for the best possible solution at each state. The better the solution found at each state, the fewer steps it will require to reach to the next state.

3) **Inference:** While searching you would come across many rules. In many cases you will be able to infer some new rules from some facts. You can build reasoning to seize a fact from other facts. The reasoning could be non-monotonic reasoning or reasoning under uncertainty.

4) **Learning:** Learning could be parametric learning, inductive learning and analogy-based learning. In parametric learning the adaptive learning process adjust the parameters of the subject that is learning. In inductive learning the learner makes generalizations from the examples and in analogy-based learning the learner makes comparisons form another similar problem or take the benefit of resemblance of this situation with others.

5) **Planning:** While a reasoning problem works for satisfying a particular condition from a given set of data and knowledge. A planning problem works for a bigger goal. It deals with the determination of a methodology for achieving a goal form the initial stages. It moves from general facts to basic facts, from basic facts to particular facts about a situation. Planning stage create an approach for achieving goals in terms of a sequence of primitive steps or actions.

19.4 EXPERT SYSTEMS

Amongst the most noteworthy developments in the field of Artificial Intelligence (AI) is the advent of "expert" or "knowledge based" systems. Joint efforts by human experts yielded systems that can diagnose diseases, fly planes, drive vehicles and configure computer systems at performance levels that can exceed the best human expertise. Question thus arises that what are expert systems? To put it most simply: Expert systems are computer programs that use knowledge to solve problems competently and successfully. They are similar to human experts in the sense that they also use logic and heuristics to solve problems, they also make errors and they also learn from their errors. This expertise is easier to store, retrieve, transfer and is cost-effective and permanent. Johnson (1983) described the term 'expert" in the most accurate manner as, " An expert is a person who, because of training and experience, is able to do things the rest of s cannot; experts are not only proficient but also smooth and efficient in actions they take. Experts knows a great many things and have tricks and caveats for applying what they know to problems and tasks; they are also good at plowing through irrelevant information in order to get at basic issues, and they are good at recognizing the problems they face as instances of types with which they are familiar. Underlying the behavior of experts is the body of operative knowledge, we have termed expertise…" Thus we can now define expert systems. Patterson (1990) described expert systems as, " An expert system is a set of programs that manipulate encoded knowledge to solve problems in a specialized domain that normally requires human expertise. An expert system's knowledge is

obtained from expert sources and coded in a form suitable for the system to use in its inference or reasoning process." You might recall the earlier description; an expert system consists of a knowledge base, database and an inference engine for interpreting the database using the knowledge embedded in the knowledge base. There is sound reasoning process that has to build in order to create an expert system.

Brief History of Expert Systems

Expert systems emerged as a consequence of the developments in the artificial intelligence field in early 70's at a few leading US universities like Stanford. They started as problem solvers using specialized domain knowledge. We will discuss a few early successful systems. This is summarized in the table given below:

Table 19.3: Brief History of Expert Systems

S. No.	Expert System	Year	Developer	Functions
1	DENDRAL / Meta-DENDRAL	Late 60's	Stanford University	Determines the structure of chemical compounds using constituent elements and mass spectrometry data. Later adapted inductive learning form
2	MYCIN/ THEIRESIUS/ GUIDON/MYSIN	Mid 70's	Stanford University	Diagnoses infectious blood diseases and determine therapies. Started with 200 rules to build over 600 rules by early 80's
3	PROSPECTOR	1974-1983	Stanford Research Institute	Assists geologists in the discovery of mineral deposits. First computer system to assist geologists.
4	XCON	Late 70's	Digital Equipment Corporation & Carnegie-Mellon University	Select and configure components of complex computer systems. Expert system work in computer systems is typified by XCON.
5	ACE	Early 80's Early 70's	Bell Laboratories	Equipment fault diagnosis and integrated circuit design. AT&T uses it for identify trouble spots in telephone networks
6	HASP/ SIAP		Stanford University & Systems Control Technology	Identifies ship types by interpreting data from hydrophone arrays that monitors regions of the ocean

(Based on *inputs from Patterson, 1990 and Waterman, 1986)*

These were some of the path setting work in the expert systems. These works provided the base for other systems to build on them. Today one can see a plethora of applications of expert systems in virtually all areas like agriculture, chemistry, computer systems, electronics, engineering, geology, information management, law, manufacturing, mathematics, medicine, meteorology, military science, physics, process control nd space technology etc.

Working Principles of Expert Systems

Expert System is a result of the interaction between the system builder (knowledge engineer) and many domain experts.

Source : *Based on Waterman, 1999*

Fig. 19.1: Building Knowledge into an Expert System

Expert systems are computer systems that are based on knowledge rather than the data. They accumulate this knowledge at the time of system building. Knowledge is programmed and kept in such a manner so that it can be browsed and appended from time to time. Expert systems possess a very high level of expertise in the area for which they are made for. The best thing about expert systems is that they grow over time and but for the initial expenditure incurred in building them, they work in a cost effective manner. Expert systems have predictive modeling power i.e. they are capable of describing the effects of new situation on the data and the solution. Expert system uses symbolic representations for knowledge (rules, networks or frames). This compilation often becomes a quick reference for best strategies, methods and consensus decisions. This becomes a permanent knowledge base. Thus, one can say that expert systems have a permanent memory. Expert systems gives access to the user to understand it's reasoning and can be used to provide training. This is possible because of its knowledge base; it can provide trainees with experiences and strategies from which to learn.

Building Expert System

The process of building an expert system is also called knowledge engineering. As we have discussed earlier that there is an interaction between the domain expert and the expert system builder which generates the knowledge into the expert system. The latter is also called "knowledge engineer". There is further to it. The remaining players in the building of the expert system are the expert system building tools, the user and the expert system itself. Let us have a quick tour on their meaning. Expert system is the collection of programs that solves problems in a particular area; domain expert is a person who is knowledgeable about that particular problem area and has solutions to those problems; knowledge engineer is a computer science expert who translates the domain expert's knowledge into the one, which is understandable by the computer; expert system building tool is the programming language that is used by the knowledge engineer to build the expert system. And finally the user is the one, which will use the expert system.

Waterman (1999) has highlighted the relationship between the two in the following figure.

Source : *Figure adapted from Waterman, 1999*

Fig. 19.2: The Players in the Expert System Game

Waterman further stated, " The figure suggests that the user may be a tool builder debugging the expert-system-building tool includes both the language, a knowledge engineer refining the existing knowledge in the system, a domain expert adding new knowledge to the system, an end-user relying on the system for advice, or a member of the clerical staff adding data to the system".

Knowledge Representation in Expert Systems

The knowledge can be represented in expert systems in three ways. These ways are rules, frames and semantic nets. A rule-based system consists of a rule-base (permanent data); an inference engine (process); and a workspace or working memory (temporary data). Knowledge is stored as rules, which are of the form

IF some condition THEN some action

For example:

IF it is hot THEN turn the AC on

IF the temperature is more than 35^0 THEN it is hot

IF the weather is not so hot but it is humid THEN also turn the AC on.

When the IF condition is satisfied by the facts, the action specified by the THEN is performed. These rules may modify the set of facts in the knowledge base. These new facts can be used to form matches with the IF portion of the rules. This matching of rule IF portions to the facts can produce "inference chains". The inference chains displays how a conclusion is reached in an expert system. Rules can be used in two ways: - by forward chaining and backward chaining.

Forward Chaining: Suppose you have a database which has some information stored in it and you want to generate some new rules and test them with respect to the database. Then by the forward chaining method you start with a fact that is present in the database. You infer some rule that comes due to a consequence of a given fact. Next is that you add that inference as fact in the database. In other words you have appended the database. Once a fact is added, it interacts with other facts

and infers some new fact that again gets added into the database. This process is continued till there is no further inference. The process is "forward" because it uses the facts on the left side to derive information on the right hand side.

Backward Chaining: Suppose you want to test whether a fact exists in the database. The process first checks the database for that fact. If the fact that you want to establish is not there, then the process tires to find other facts that conclude that fact. It tries to establish those facts first, which conclude the fact you are interested in. The process continues in the same manner till sufficient evidence is found for existence/non-existence of the fact being tested.

The essential difference between forward chaining and backward chaining is in the way the facts are searched in the database. In some situations, backward chaining proves to be cost-effective. If your intentions were to infer a particular fact then by employing forward chaining you would waste a lot of time and efforts. This is because of the fact that experts systems are generally based on hundreds and thousands of facts. On the other hands if you were looking for some new information from the database then by forward chaining you would be able to find a lot of rules that will be executed as a consequence of the existing facts. Forward chaining can derive a large number of inference chains and situations. These facts and rules could be further used to append the database.

Activity A

1) You must have used a word-processor and used its spelling and grammar-checking feature. What additional features would you intend to have for the grammar-checking module? Mention the limitations you have observed in your word-processors module.

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2) Mention five activities that you encounter in your day-to-day life that could be not solved by mathematical or logical algorithms. Take one such example and solve it (up to 2-3 stages only) by intuitive approach as done in AI systems.

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19.5 NEURAL NETWORKS

Neural networks are a great aid to computing. They involves mathematical structures that are capable of learning. Neural network is a set of connected input/output units where each connection has a weight associated with it. Neural networks are primarily used for predictions. Neural networks use past data and fit a model on it to predict and classify. Neural networks as the name suggest resembles the namesake found in human beings. Neural networks begin with an input layer, which is given some weight before it connects to the output unit. The output unit processes the values of input variable and weights with a combination function. There are many hidden layers between the input and output layer. A neural network is trained by assigning weights on the inputs of each of the units so that the network predicts the variable under question in the best possible manner. According to Barry & Linoff (2001), "Neural Networks are a good choice for most classification and prediction tasks when the results of the model are more important than understanding how the model works. Neural Networks actually represent complex mathematical equations, with lots of summations, exponential functions and any parameters. These equations describe the neural network, but are quite opaque for human eyes… Neural networks do not work well when there are man hundreds or thousands of input features… Neural network works well with decision trees… decision tress are good at choosing the most important variables- and these can be used for training a network."

A major difference between neural networks and the statistical modeling is that the former is based on the rules it explores from the data while the latter is based on previously specified functional form.

As our nervous system is made up of neurons that are connected with a nerve fiber, neural nets also have nodes that are connected. As a neuron receives signals from its neighboring neurons, processes them and move those signals forward, the neural net also do the same functions.

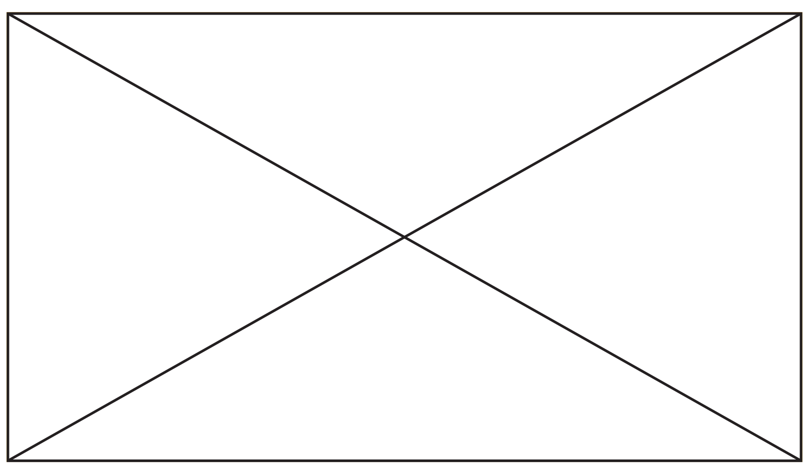
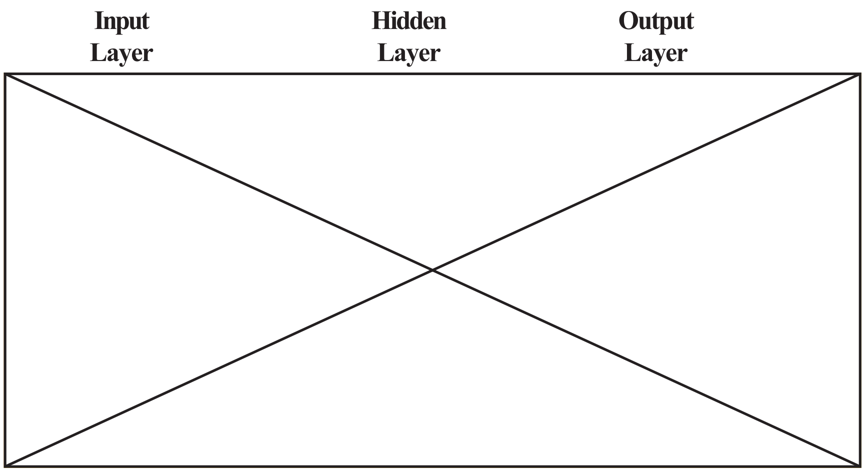


Fig. 19.3 : A Single Node Neural Network

Thus artificial neural networks are electrical analogues of the biological neural nets. The most common application of neural network is in the field of machine learning. One can find many applications of neural networks in control, automation, robotics, computer vision, scheduling, knowledge acquisition and planning. They are useful in many applications because they derive meaning from complicated or imprecise data. These situations are otherwise complex and undetectable by humans and other computer techniques. Neural Networks are good at identifying patterns or trends in data and hence they are well suited for prediction and forecasting needs.

A neural network can have multiple layers. Suppose, we have a training data and we measure attributes for training data. These measured attributes form the input layer. Weights are given to the input layer according to their importance in the problem. The output from the input layer is assigned some weights and this feed to the second layer, known as hidden layer. Similarly the weighted outputs of this hidden layers can be fed to the next hidden layer and so on. Finally these outputs go into the output layer, which emits network's prediction. This process is explained in the figure given below. Figure shows how a training sample $x_1, x_2, \ldots x_i$ is fed to the input layer. Weighted connections exist between each layer denoted by $w_{ij.}$

If there is a single hidden layer then the network is called a two-layer neural network. Similarly a network containing two hidden layers is called a three-layer neural network.



Source: *Han & Kamber(2001)*

Fig. 19.4 : A Multilayer Neural Network

Business Applications of Neural Networks

There are immense applications of Neural Networks in business. It is just not possible to mention all of them. However an attempt has been made to give you a glimpse of the purposes for which neural networks are being applied. Following are some of the applications of the artificial neural networks Pujari (2001), Konar (2000):

1) Used in investment analysis to predict the movement of stocks, currencies etc., from previous data. They have become worthy successors of linear models.

2) Used in monitoring the state of aircraft engines. Parameters like vibration levels and sound are used to predict or forecast engine problems.

3) Used to improve marketing mailshots. They are employed to find a predictive mapping from the known data about the clients and their response. This mapping is then used to direct further mailshots.

4) A simple neural network based diagnostic expert system, which diagnoses and recommends treatments for acute sarcophagal disease.

5) In the development of a system for criminal investigation for voice classification scheme. A multi layered feed forward neural net was trained. Speech features of the suspect are supplied to the neural net, which then processes the output signals.

6) In path planning of the mobile robots. Mobile robots works on sensors that help them recognize the world as the humans do. Neural Network based navigational model has been applied for online navigation of such robots. They help the robot to receive sensory information, generate control commands for motion and direction and finally set the schedule of motions.

7) For acquisition of knowledge in an expert system. Fuzzy neural networks are applied for automated estimation of certainty factors of knowledge from proven and historical databases of a typical reasoning system.

8) In recognition of human faces from their facial images. Self-organizing neural nets are applied for this task. Weights are given to each multi-dimensional point on the 2-d plane and then it is mapped to a single point. This process is repeated for all the 360 images (corresponding multi-dimensional points.)

9) In cognitive learning for applications in psychological modeling. Fuzzy neural networks are used to mimic the activities of "long term memory" of the biological cognitive system.

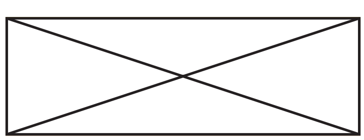
These applications are never-ending. As said earlier, neural networks are useful in many applications because they derive meaning from complicated or imprecise data. These situations are otherwise complex and undetectable by humans and other computer techniques. We now move on to another important concept i.e. fuzzy logic and its business applications.

19.6 FUZZY LOGIC

Traditional logic has many limitations when one deals with uncertain and incomplete knowledge. Unfortunately knowledge in the real world is never certain and complete. Fussy logic came into picture as a concept that extends the expressive power of traditional logics. You would recall that in standard set theory, an object is either a member of a set or it is not. There is no middle way. There is no partial containment. The characteristic function of a traditional set assumes values 1 and 0, on the basis of membership. If we generalize this concept and allow the characteristic function to assume all values between 0 and 1, then we talk about the fuzzy sets and the value assumed by the characteristic function denotes the degree or level of membership.

Prof. Zadeh of University of California, Berkley in 1965, first introduced fuzzy sets. The main objective was to define the fuzziness and vagueness. Fuzzy set theory forms the basis of Fuzzy logic. It is a relatively new discipline that has found applications in automated reasoning of expert systems. Fuzzy models require defining of memberships functions. These functions can often be defined on the basis of intuitive knowledge. Because of their simplicity to use and cost effectiveness, fuzzy logic and fuzzy computation are good prospects for the next generation expert systems. The universe of fuzzy set can take any value in the real interval 0 and 1. Let us take an example to explain the concept better. Suppose we want to define the membership of batsmen of national level in a country.

We may define the membership characteristic function *u* as follows.



for $0 \leq \times \leq 50$

1

for $x > 50$

here x is the national average of the batsman. The interpretation is if a batsman has an average of more than 50 runs he is strong member of the fuzzy set. An average of 40 means his membership is partial with $u_A(x)=0.5$, similarly an average of 30 would get $u_A(x)=0.2$ and so on. The characteristic function for fuzzy sets provides a direct linkage to fuzzy logic.

Business Applications of Fuzzy Logic

1) Fuzzy matching is used in matching problems that is an essential operation in speech recognition, automated reasoning and expert systems. Computing fuzzy distance between two objects forms the basis of such matching.
2) Fuzzy relations are used in modeling a physical system, whose variations of output parameters with input parameters are known.
3) Fuzzy logic has been applied in management of ambiguity of the data by analyzing the knowledge about predecessors to determine the truth-value of a proposition.
4) Fuzzy reasoning is used for identifying criminals from imprecise and inconsistent word description of criminal history.
5) Fuzzy logic is used in medical diagnostic systems in identifying diseases on the basis of symptoms by calculating fuzzy beliefs.

There are many other uses of Fuzzy logic like its applications in specialized belief networks called Fuzzy Petri Nets (FPN) but are beyond the scope of this introductory unit.

19.7 GENETIC ALGORITHMS

Genetic algorithms are stochastic algorithms. They were first proposed by Holland in 1975. They are based on the natural process of biological evolution. These methods follow the "Survival of the fittest" principle of Darwin. They are called "genetic" because they work on the same principles as genetics: The members, which adapt well to the environment, are selected for reproduction and produce offspring. Poor performers die without offspring.

Fig. 19.5 : Process of Genetic Algorithms

The figure above can be summarized that genetic algorithms let the data structures face the environment and carry forward with only the fittest data structures. There are a few concepts that need to be highlighted.

Mating: Mating is done by randomly selecting a bit position in the eight bit string and concatenating the head of one parent to the tail of the other parent to produce the offspring e.g. the fifth bit crossover point of parents xxxxxxxx & yyyyyyyy will produce offspring xxxxxyyy & yyyyyxxx.

Inversion: Inversion is done on a single string. The inversion concatenates the tail of the string to the head of the same string e.g. sixth bit inversion of string abcdefgh will be ghabcdef.

Mutation: In mutation bits at one or more randomly selected positions are altered. It is done to ensure that all locations of the rule space are reachable so as to avoid local minima.

Business Applications of Genetic Algorithms

1) Genetic algorithms have been used in intelligent search problems. These problems include games, routing problems in VLSI circuits and navigational planning of robots.

2) Genetic algorithms have been used in many optimization problems like the traveling salesman problem and the job shop scheduling problems etc.

3) Genetic algorithms and artificial neural networks together have many applications in machine learning such as adaptive control etc.

4) Genetic algorithms are used in data mining for the tasks of hypothesis testing and refinement, optimal decision tree induction and event prediction etc.

5) Genetic algorithms are also used in classification problems and for evaluating the fitness of other algorithms.

Activity B

1) Identify and describe two good applications areas for artificial neural networks and fuzzy logic within a university environment.

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2) Suppose you want to define the membership of young people. Think of a membership characteristic function *u* and calculate its value for different ages. You can take a person as young if he is less than 30 years of age. Also, plot the values of the membership function with respect to age.

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19.8 SUMMARY

To overcome the difficulties that were faced in solving many real-life problems, intelligence was put into a computer (essentially based on the knowledge of the then society). The theme of all these efforts was around the concept of making a program intelligent, by providing it with high quality specific knowledge about some problem area. This collaborative and collective intelligence led the machine do the tasks better than the humans. AI has taken off from there and what we are getting today is an improved build-up on the older systems. Expert systems emerged as a consequence of the developments in the artificial intelligence field. They started as problem solvers using specialized domain knowledge. As the time passed by these systems kept building on themselves and what we are getting today is much better versions of their predecessors. More and more algorithms and methods were developed to solve problems more efficiently.

Some of these include artificial neural networks, fuzzy logic and genetic algorithms. They have immense applications in the field of AI and expert systems. Genetic algorithms are used with neural networks and fuzzy logic for solving more complex problems. They are jointly used and hence are often referred as "soft-computing". This unit has tried to provide you with an introduction of these developments.

19.9 UNIT END EXERCISES

1) What do you understand by Artificial Intelligence? What are the factors that highlighted the need of developing AI? What are the goals of AI?

2) Discuss the application of AI with respect to the developments in the field of computers. Also discuss the major works that typically describes the earlier work done in AI.

3) If you have to build artificial intelligence in your organization, what factors you would think of and take into consideration. Mention those factors in a stepwise manner.

4) Define Artificial Intelligence and mention some of its current applications.

5) What are expert systems? Mention the working principles of expert systems. Also discuss how knowledge can be represented in expert systems.

6) What are artificial neural networks? Discuss their business applications.

7) Discuss the salient features of the genetic algorithms. How do they differ from the artificial neural networks? Explain mutation and mating with the help of examples.

8) What are the factors that differentiate traditional logic and fuzzy logic? Explain the concept of membership characteristic function and also discuss the Business applications of Fuzzy Logic.

19.10 REFERENCES AND SUGGESTED FURTHER READINGS

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